International Space Station (ISS)

Impacts from Columbia Tragedy & Challenges for Completing the ISS

NASA Annual

Risk Management Conference V

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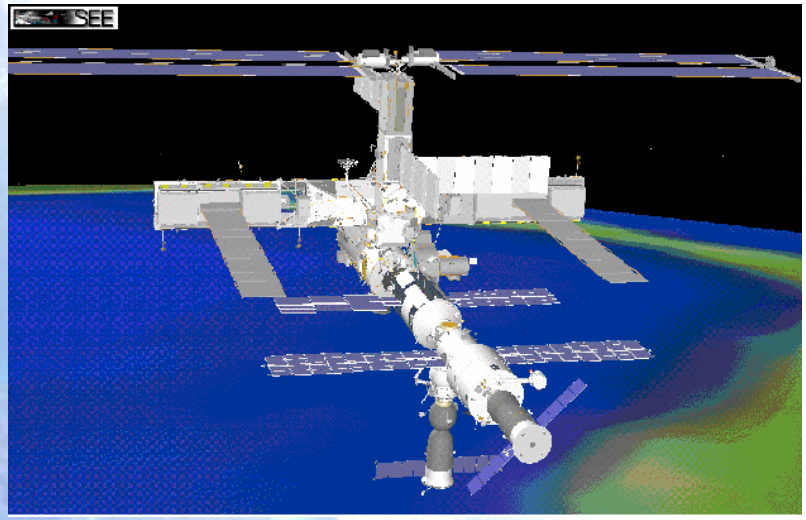
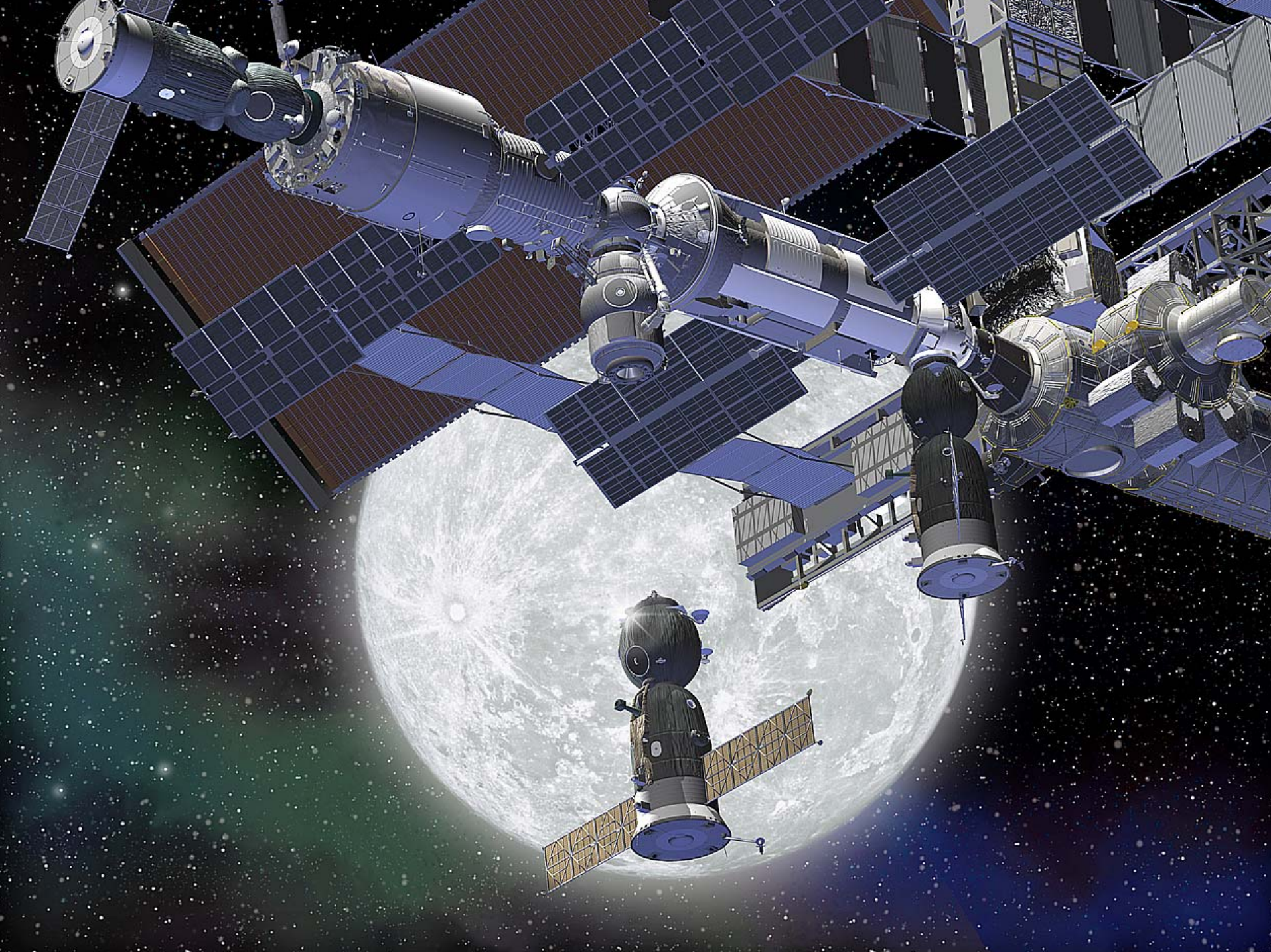
Agenda

- *ISS - January 2003*
- *Impacts from Columbia*
- *ISS Re-planning*
- *Examples of Applied Risk Management*
  1. *3 v. 2 v. 0 Crew - PRA*
  2. *2 crew EVA with no IVA crewmember present – Risk Trade*
  3. *EVA in the Russian Orlan Suits versus the USOS EMUs – Risk Trade*
  4. *Increase of risk due to the CMG Repair EVA over a nominal EVA - PRA*
- *Future Challenges*



Simulated Views Of ISS
Courtesy of SimStation


BROWN
CLARK
CHAWLA
ANDERSON
RAMON
HUSBAND
MCCOOL
STS 107



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ISS Program Risk Management System

- *Program-wide **risk management database** called ISS Risk Management Application (IRMA) to manage risks and communicate risk data throughout all ISS managing organizations. Each ISSP managing organization use this database application to effectively manage and track each risk and to gain insight into impacts from other managing organization risks including cost issues.*

- ***Probabilistic Risk Assessment (PRA)** for ISS.*
  - ***Develop ISS trade studies to aid in decision-making process in support of design, operations, and upgrade alternatives.***
  - ***Captures possible accident scenarios that may lead to several undesired consequences called "end-states". The ISS PRA goals are to examine those end-state scenarios that can lead to:***
    - ***Catastrophic loss of the Station***
    - ***Loss of a Station crewmember/injury of a Station crewmember***
    - ***Loss of a vital Station system***
    - ***Loss or shutdown of a Station pressurized module***
    - ***Situations requiring Station evacuation***
    - ***Loss of Station related science***
  - ***The PRA model calculates the probability of reaching these end states and the statistical uncertainty associated with each.***
  - ***The level of detail is modeled to the ORU level.***

Management Challenges

- *Risk Management techniques assists in management decisions in the re-planning of the ISS Program during the Shuttle Program grounding*

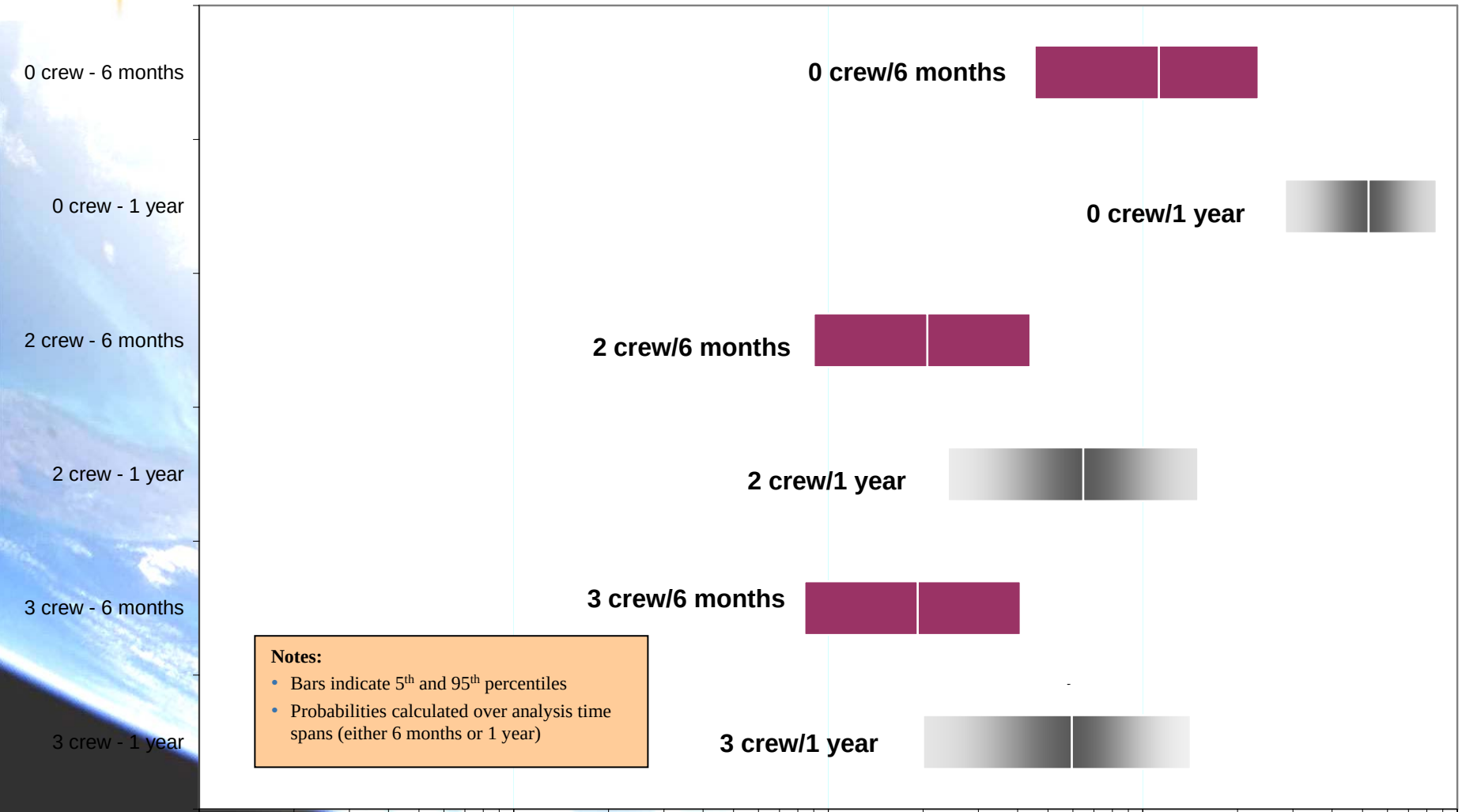
- *Risk Management as a "decision support tool" provides valued insight and helped confirm decisions and data brought forward in other forums and processes*

Risk Management Applied to ISS #1

- *Challenge:*
  - *Assist management in determining best option for **continued crewing of ISS***

- *Application of Risk Management:*
  - *Performed Probabilistic Risk Assessment (PRA) looking at "Loss of Vehicle" (LOV) end state for **3 versus 2 versus 0 crew**.*

Loss of Vehicle Results



Summary

- *Making spares available for repair should be considered for the ECLS System failures (Ability to repair ECLSS subsystems reduces risk of LOC)*

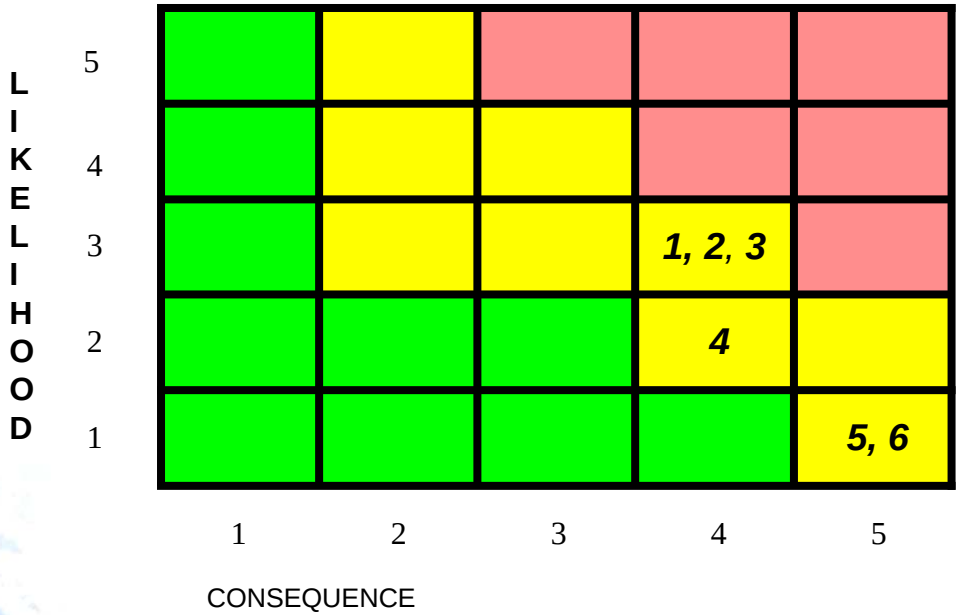
- *There is a range in which repair using spares is most significant given that the repair action may not be 100% reliable*

Risk Management Applied to ISS #2

- *Challenge:*
  - *Assist management in better understanding risk of **conducting a two crew EVA with no IVA crewmember present***

- *Application of Risk Management:*
  - *Conducted risk trade of hazard controls that are implemented by IVA crew member.*
  - *Ensure hazard control functions normally conducted by IVA crewmember are controlled by alternate means.*
  - *Map those risks on Matrix.*
  - *Conduct PRA to quantify increase in "Loss of Vehicle" (LOV) end-state with and without IVA Crewmember*

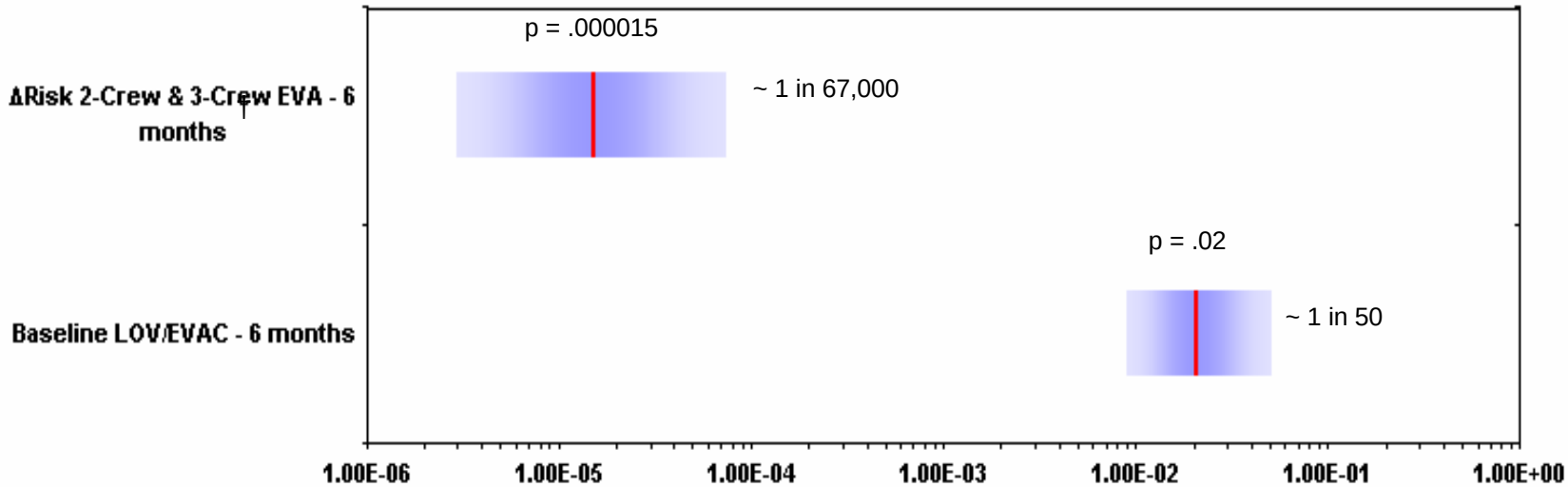
Program Risk Matrix – 7S Delta FRR Update



1. **Loss of Attitude Control – 3x4** *[Infrequent/Moderate x Major Reductions but work-arounds available]*
   - *Configuration inhibits RS thrusters, maintaining USOS attitude control but redundancy has been removed. LOAC failure requires Ground intervention and increases time to react by Ground.*
2. **Loss of DDCU LA2A or LA4A – 3x4** *[Moderate x Major Reductions but work-arounds available]*
   - *Configuration maintains USOS attitude control but redundancy has been removed. EPS failure requires Ground intervention and increases time to react by Ground.*
3. **Loss of ITCS Cooling – 3x4** *[Moderate x Major Reductions but work-arounds available]*
4. **Inability to repress DC-1 – 2x4**
5. **Fire Event On-Board ISS – 1x5**
6. **Depressurization of ISS – 1x5**

Probability of Loss of Vehicle Over 6 Month Period

- ***Quantitative assessment results showed slight increase in risk of Loss of Vehicle (LOV) during an 8 hour EVA due to no IVA crewmember***
- ***Marginal increase in Risk of LOV when compared to the nominal LOV probability (5 orders of magnitude)***



† Error bars generated by order-of-magnitude estimate

- ***Change in Risk of Loss of Vehicle per:***
  - ***EVA: 1 in 200,000***
  - ***3 EVAs in a 6-month mission: 1 in 67,000***

Risk Management Applied to ISS #3

- *Challenge:*
  - *Assist management in better understanding additional risk of* ***conducting a two crew EVA in the Russian Orlan Suits versus the original plan of using USOS EMUs***

- *Application of Risk Management:*
  - *Same as previous case with the addition:*
  - *Map the difference in risk of the IVA controlled Hazards for an Orlan versus EMU EVA*

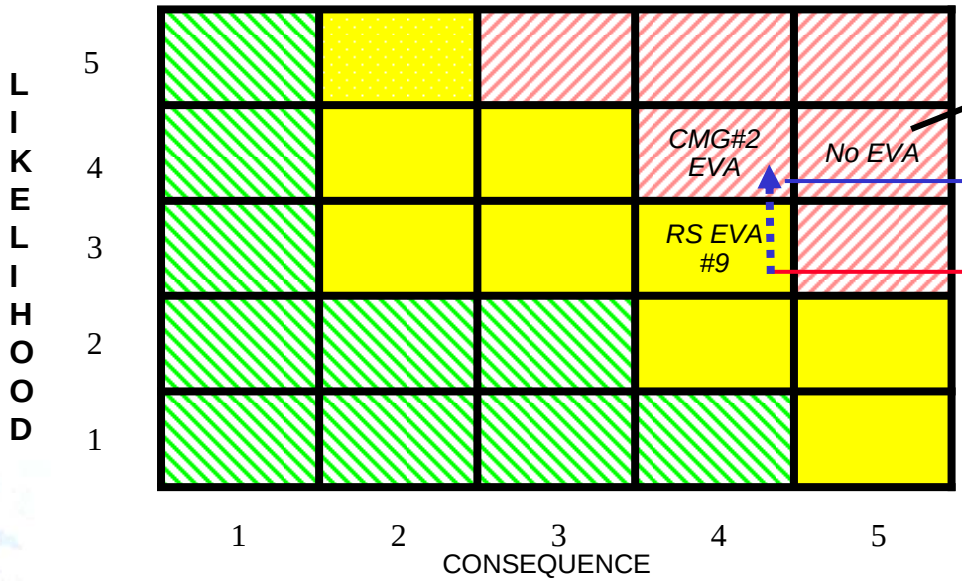
Risk Management Applied to ISS #3

CMG#2 EVA vs. RS EVA#9

Green

Yellow

Red



USOS attitude control not regained: 4x5: *Risk increase to major milestones RS EVAs #10 & 11*

Contingency CMG#2 RPC EVA: *4x4: Orlan EVA on USOS - increases crew re-ingress time for intervention if required;*

RS EVA#9: *3x4: Performing RS EVAs in the two-crew configuration without IVA crew. USOS attitude control redundancy in place.*

DELTA CHANGES SINCE Russian Segment EVA#9:

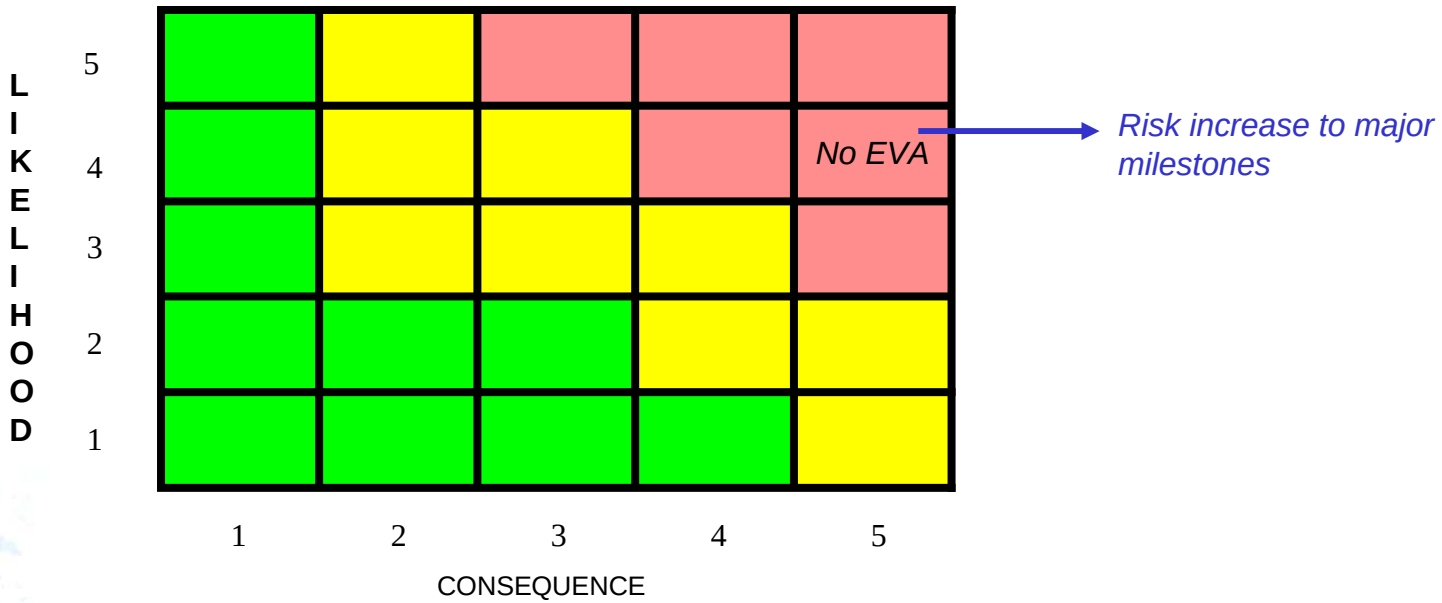
- **Loss/Intermittent Comm – 4x4 [High x Major Reduction but work-arounds available, EVA abort if necessary]**
- **Loss of Attitude Control – 3x3 [Moderate x Moderate Reduction but work-arounds available]**
  - CMG#2 EVA: RS attitude control only. USOS 0 FT for attitude control with 2 of 4 CMGs available but inactive for EVA.
- **Loss of DDCU LA4A – 4x3 [High x Moderate Reduction but work-arounds available]**
  - For EVA, LA2A removed from power increases risk to loss of systems on that channel. EPS failure requires intervention. Time-to-react is planned to be lower than time-to-effect.

NOTE: ITCS, Fire, and Depress not shown on this chart due to loss of ITCS, Fire, Depress risk does not change.

SUMMARY: Risk of not performing the EVA outweighs the risk to performing the EVA. Regaining USOS attitude control redundancy is in the critical path of RS planned EVAs 10&11 and RS Software Load. Efforts focused on providing interim controls to maintain safety and reduce risk.

Risk Management Applied to ISS #3

ISS Risk To Not Performing CMG #2 EVA



- **Not performing CMG#2 EVA [4x5]**
  - **Inability to perform RS EVAs due to LoAC risk**
    - **Inability to outfit the SM for ATV docking. Impacts ATV schedule.**
  - **Increases risk to future ISS assembly**
  - **Increases risk to future contingency EVAs**
  - **Schedule 4x5 = High, requires different process/approach x Cannot Achieve Major ISS Program Milestone**

- **Following CMG#2 EVA reduces risk to ISS and achieving mission objectives**
  - **Regains USOS Attitude Control Fault Tolerance**
  - **Reduces risk to future ISS assembly**
  - **Decreases risk and vulnerability to LoAC during operations such as RS EVAs**

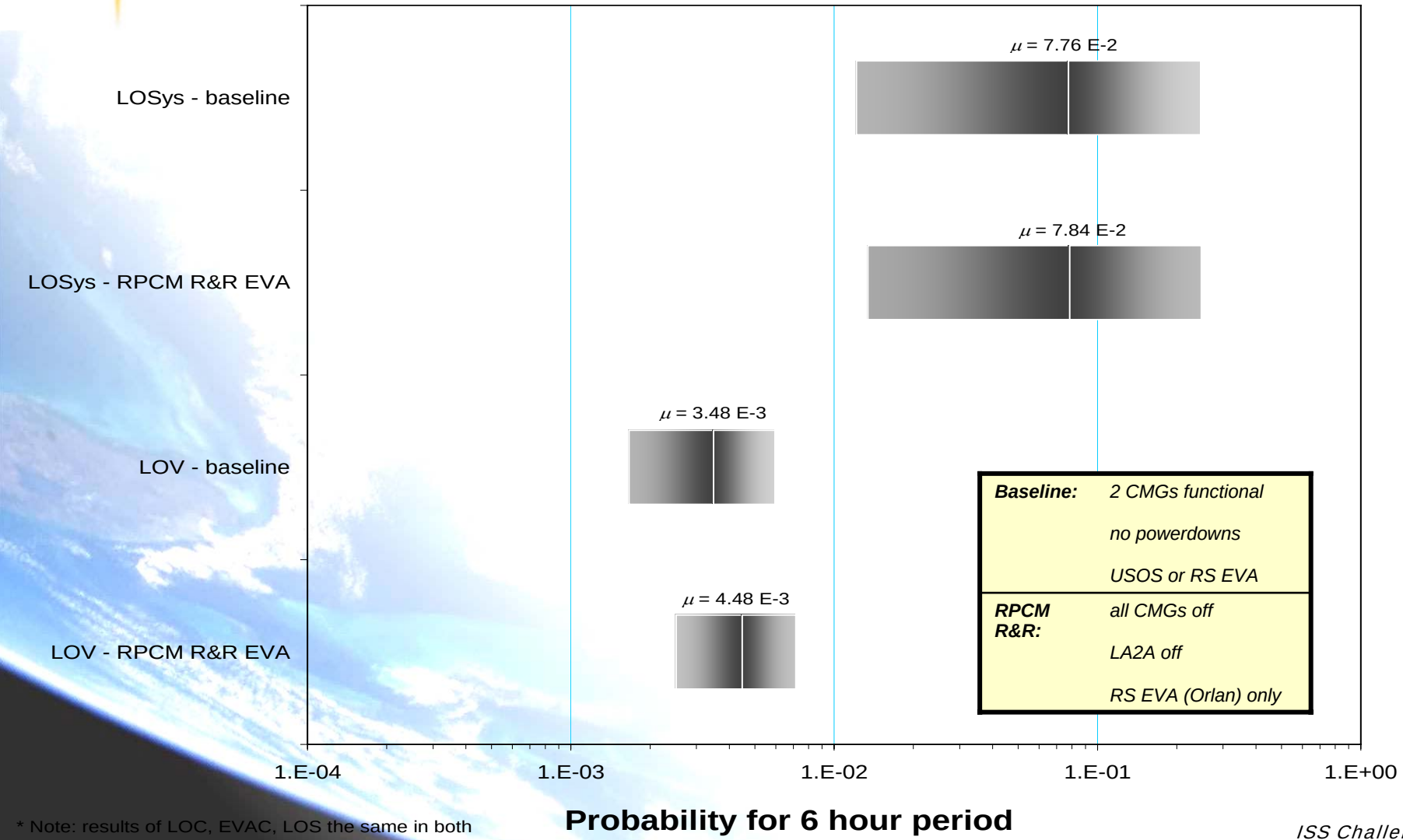
Risk Management Applied to ISS #4

- *Challenge:*
  - *Assist management in better understanding the increase of risk due to the CMG Repair (RPCM R&R) EVA over a nominal EVA with functioning CMGs and all power channels operational*

- *Application of Risk Management:*
  - *Performed a Probabilistic Risk Assessment (PRA) quantifying "Loss of Vehicle" end-states CMG Repair EVA versus a nominal EVA*

Risk Management Applied to ISS #4

No significant change in critical end states

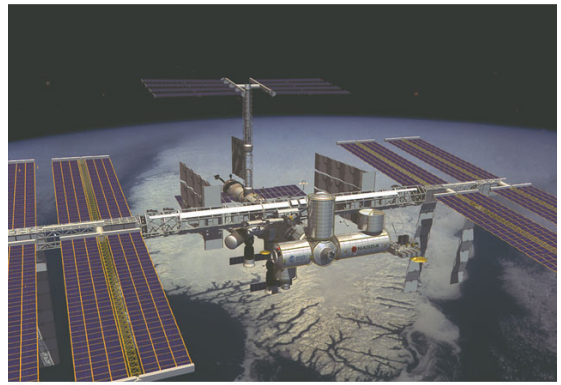


* Note: results of LOC, EVAC, LOS the same in both

Discussion of Results

- *Loss of CMGs only significantly affect maintenance of micro-g environment for science*
- *Slight increase in Loss of Vehicle (LOV) end state due to loss of non-propulsive attitude maintenance capability with CMGs*
- *No significant change in risk of critical end states due to the EVA*

Future Challenges



- *Completing Station with limited time and limited budget*
  - *Sustaining ISS with the Russian Assets of Soyuz and Progress*
  - *Return to Flight*
    - *May 2005 (as planned)*
  - *Two additional international visiting vehicles to ISS*
    - *ATV – October 2005*
    - *HII Transfer Vehicle (HTV) – July 2008*
  - *Adding two additional international laboratories*
    - *ESA/Columbus Module*
    - *JAXA Experimental Module*

- *Restructuring program to operate successfully post Shuttle Retirement in 2010.*
  - *Station was designed like a latex glove around the capabilities of the Shuttle*
  - *Major restructuring to science and sparing is required*

Future Challenges

- *Fulfilling goal of science and utilization*
  - *Vision says:*
    - *Permanent international presence of humans in space - Successful*
    - *A human outpost in space bringing nations together - Successful*
    - *Benefit of life on Earth and beyond - TBD*
    - *We will make revolutionary discoveries - TBD*
    - *Advance exploration of our solar system - TBD*
    - *Enable commerce in space - TBD*
- *Increasing crew size*
- *New Mission: Engineering Test Bed for Moon & Mars*


HARDA